WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: KY2441

Title: Developmental stability as an indicator of amphibian population health and environmental degradation

Focus Categories: Water Quality, Toxic Substances

Keywords: bioindicators, conservation biology, pollutants, monitoring

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Congressional District: First

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Abstract

One of the most important, yet most difficult, tasks associated with conservation of any organism is the identification of populations subject to stress before such stress has a detrimental effect. This is particularly true of amphibians; the global decline of amphibians is considered a disturbing indicator of environmental degradation because it may forebode of cascading ecological effects, as well as raising health concerns about human populations. Amphibians are ideal biological indicators, because their semi-permeable epidermis and complex life cycle expose them to multiple stressors in both aquatic and terrestrial environments, and thus they should be among the first vertebrates affected by anthropogenic stressors in either of these environments. Furthermore, some of the same stressors affecting amphibians are known to have negative effects on other species, including humans. Biologists thus need an early-warning system that could identify environmentally-stressed animals before the stressor causes population and/or regional harm. Such an indicator should be able to measure stress-induced effects before drastic changes in morphology take place which would subsequently decrease the organism's survival and reproductive abilities. One such indicator is obtained by measuring developmental stability, the ability of an organism to develop normally under a range of environmental conditions. One of the most widely used measures of developmental stability is fluctuating asymmetry (FA), nondirectional differences between the left and right sides of the body. Previous research in my laboratory has shown that FA is correlated to human-induced stressors in one amphibian species. I propose to continue my studies of developmental stability as a biological indicator of stress in amphibian populations, in an effort to improve the ability of biologists to evaluate the health of these populations, the surrounding aquatic and terrestrial ecosystems, and the possible environmental risks to humans.

In collaboration with graduate and undergraduate students, I propose to correlate amphibian FA with: 1. water chemistry parameters known to cause deformities and mortality in amphibians; 2. land use practices (forested, agricultural, industrial); 3. density of larvae, which at high levels can induce stress; and 4. adult population size, which may affect FA via inbreeding depression in small populations. Population estimates will thus allow separation of natural stress levels from those that may be human induced (via water chemistry), which a recent NSF workshop identified as a critical goal of amphibian conservation (Wake

1998). I predict that FA will increase with decreased water quality, increased human land use (disturbance), increased larval density, and decreased adult density. I also expect significant relationships between water quality and land use. I also propose experiments to elucidate the cause and effect between FA and environmental stressors. Specifically, I propose to conduct several laboratory experiments with amphibian embryos and larvae to understand the how FA changes in response to chemical stressors.

Thirty ponds of varying hydroperiod have been chosen for study, with ten ponds each from forested, agricultural, and industrial sites across western Kentucky. At least 25 larvae and 12 adults of each species will be sampled from each population. Both larvae and adults will be captured to assess the potential short-term (larvae) and long-term (adult) effects of stressors on FA. Each individual will be photographed with a digital camera. Measurements of FA using digital images will concentrate on morphological structures directly related to amphibian fitness, particularly measures of the head which have been shown to exhibit significant FA in bullfrogs and salamanders. Larval density and adult population size will be estimated using standard techniques. Water chemistry will be assessed at each pond bi-monthly. FA, amphibian density and adult population size, and water chemistry will be analyzed across land use types using a MANOVA to test the hypothesis that land usage influences each set of variables simultaneously. Further analysis will include correlation of FA with water chemistry within and between habitat types. Experiments will consist of rearing embryos and larvae in buffered water with target stressor chemicals. Groups of ten embryos will be reared in 200ml watch glasses, and then transferred to aquaria after hatching with ad lib food. Larvae will be reared for four weeks and then processed as above. We will use ANOVA to analyze the effects of each chemical treatment on larval FA.

The results of this study will provide the data necessary to evaluate the use of FA as an indicator of amphibian stress and environmental degradation. Development of FA analyses will provide researchers with a robust biological indicator of environmental health, which can potentially be used to monitor areas sensitive to ecological disturbance or where there are human health concerns. The proposed research will thus be important to both species conservation and environmental monitoring.